EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR HEALTH AND FOOD SAFETY

Crisis preparedness in food, animals and plants
Animal health

SUBMISSION OF ERADICATION PROGRAMMES FOR CATEGORY B AND C DISEASES OF TERRESTRIAL ANIMALS BASED ON GRANTING DISEASE-FREE STATUS AT ESTABLISHMENT LEVEL

Template in accordance with Article 10 of Commission Implementing Regulation (EU) 2020/2002

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1. Date of submission October 2021

2. Member State : UK (NI)

3. Name of the disease[1] Bovine Tuberculosis

4. Contact details

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   b. Responsibility within the competent authority Policy Officer

   c. Name : Lee Williamson

5. Territorial scope with a description and demarcation of the geographical and administrative areas covered by the eradication programme and the names of the zones and regions, if more than one region is included in the territorial scope of the programme.

   Northern Ireland (NI)

6. A description of the epidemiological situation for each zone or region, if more than one region is included in the territorial scope of the programme:

   (a) the number of establishments keeping animals of the targeted animal population by health status (Disease-free, infected or unknown) excluding establishments falling under the derogation referred to in point (6)(f) at 31 December;

   (b) the number of animals of the targeted animal population kept in the establishments referred to in point (a) by health status;

   (c) maps indicating the density of the targeted animal population referred to in point (b) by health status;

   (d) timeline with prevalence, incidence data and, where relevant, vaccination history covering at least the past 5 years; and

[1] This template is to be used for the submission of the following eradication programmes for the following listed diseases:

Category B-diseases

a) Infection with Brucella abortus, B. melitensis and B. suis

b) Infection with Mycobacterium tuberculosis complex

Category C-diseases

a) Enzootic bovine leukosis

c) Infectious bovine rhinotracheitis/infectious pustular vulvovaginitis

d) Infection with Aujeszky´s disease virus

e) Bovine viral diarrhoea

(e) information as regards the epidemiological situation in additional animal populations, where relevant.

Current epidemiological situation in NI

6.1 The submission of the Northern Ireland (NI) bovine Tuberculosis (bTB) programme to the European Commission did, in previous years, form part of the overall submission for the United Kingdom (UK). However, as previous UK programmes noted, NI is epidemiologically and geographically distinct from Great Britain and has developed and implemented a separate programme since controls began. Efforts to control bTB in Northern Ireland began in the late 1940s with compulsory testing introduced in 1959. Overall, while there has been success in maintaining disease at low levels, this has fallen short of eradication. Disease levels did begin to increase in the late 1990s and grew further in the early 2000s in the aftermath of the Foot and Mouth Disease outbreak (which caused bTB testing within the programme to be severely interrupted in 2001). Following this peak, disease levels declined again between 2004 and 2007.

6.2 Herd incidence (defined as the number of new reactor herds during the past 12 months as a proportion of the herds which have presented cattle for a bTB test during the same period) was relatively level from 2007 to 2010 followed by a sustained rise during 2011-2012, peaking at 7.46% in October 2012. Herd incidence then steadily declined to a low of 5.95% in September 2014, followed by another rise which was particularly steep throughout 2017, to 9.73% in November 2017.

6.3 In response to this increase, additional disease controls measures were introduced in late 2017/2018 including the increased use of severe interpretation of skin test results. The disease picture improved slowly in 2018 and 2019 with the annual herd incidence figure for 2019 standing at 7.85%. However since then, the decline has halted and in recent months the underlying trend in herd incidence has been fairly static, the latest available figure being 8.59% for the 12 months to the end of August 2021.

6.4 Changes in annual animal incidence show a similar trend, steadily increasing during 2011-12 to a high of 0.674% in November 2012, followed by a decrease to a low of 0.502% in March 2014 and then a rise throughout 2015-6. Throughout 2017 animal incidence (defined as the number of reactor animals during the last 12 months as a proportion of the cattle which have been presented for a bTB test during the same period) increased more steeply in line with the sharp rise seen in herd incidence, reaching a peak of 0.920% in November 2017. As with herd incidence, animal incidence has declined since then, before stabilising with the latest figure being 0.760 in August 2021.

6.5 At the end of December 2020 there were 23,023 operational cattle herds (including no stock herds) registered in Northern Ireland, containing 1,720,278 animals. Of these, 19,526 herds (1,289.735 animals) were Officially Tuberculosis Free (OTF), 2,068 herds (322,472 animals) were Officially Tuberculosis Free Withdrawn (OTW), and 1,429 herds (108,071 animals) were Officially Tuberculosis Free Suspended (OTS) including herds with overdue tests.

In 2020, 22,058 herds (approximately 1.72million cattle) were skin tested. Approximately 3.1M animal tests were carried out, a 4.3% decrease from 2019 (3.24M). In light of the difficulties faced from March 2020 as a result of the Covid-19 pandemic, and in order to adhere to Public Health Agency guidance on social distancing measures, these figures compare favourably to 2019, when 22,394 herds and approximately 1.73 million individual cattle were tested. In addition, in 2020:

• There were 12,852 tuberculin skin test reactors, a 1.28% decrease from 2019 (13,019 reactors).

• There were 1,861 new bTB reactor herds, a 5.9% increase from 2019 (1,757 herds).

• 22,288 animals were IFN-gamma tested, with 870 removed solely based on IFN-gamma results, compared with 22,428 animals tested and 538 removed solely based on IFN-gamma results in 2019. Plans to expand the use of IFN-gamma testing in 2020 were hindered as the result of Covid-19 pandemic affecting the amount of testing which took place in spring 2020.

• 714 animals were removed as direct contacts, compared with 673 during 2019.

Lesions at routine slaughter (figures exclude animals imported for direct slaughter):

• 2,270 animals were found with bTB-like lesions at routine slaughter (0.52% of animals slaughtered). 1467 of these (64.63%) were confirmed as bTB by histology and/or bacteriology. This compares with 2,096 animals found with bTB-like lesions at routine slaughter in 2019 (0.489% of animals slaughtered), an increase of 7.87% of which 1,270 (60.59%) were confirmed.

• 363 bTB breakdowns were triggered by an animal found with bTB-like lesions at routine slaughter which was subsequently confirmed by histology and/or bacteriology, compared to 408 bTB breakdowns in 2019.

• 665 herds were restricted as a result of finding bTB-like lesions at routine slaughter, compared to 724 herds in 2019. (This includes cases where laboratory testing gave an alternative diagnosis e.g. actinobacillosis.)

• In 248 herds a bTB-like lesion at routine slaughter triggered a breakdown where 1 or more reactor animals were disclosed at the resulting skin test. 246 herds were similarly affected in 2019.

bTB confirmation:

• bTB was confirmed 2,154 herds in the 12 months to the end of December 2020, a 0.28% decrease compared to the previous 12 months (2,160).

• bTB was confirmed in 6,528 animals in the 12 months to the end of December 2020, a 0.62% decrease compared to the previous 12 months (6,569).

6.6 Official bovine bTB statistics for N Ireland are published monthly and are available online at https://www.daera-ni.gov.uk/articles/tuberculosis-statistics-northern-ireland .

7. A description of the disease control strategy of the eradication programme in accordance with Article 16 of Commission Delegated Regulation (EU) 2020/689 including at least:

(a) the sampling schemes and diagnostic methods to be used in accordance with Annex IV to Delegated Regulation (EU) 2020/689:

(i) for the granting of the disease-free status to establishments and the maintenance of that status;

(ii) to confirm or rule out the disease in the event of a suspected case;

(b) disease control measures to be applied in the event of a confirmed case;

(c) biosecurity and risk mitigating measures to be implemented;

(d) type of vaccine(s) to be used and the vaccination scheme, if relevant;

(e) measures to be implemented as regards additional animal populations, if relevant;

(f) derogations to be applied in accordance with Article 19 of Delegated Regulation (EU) 2020/689, if relevant;

(g) coordinated measures with other Member States or third countries, if relevant.

(h) targeted animal populations and when applicable, additional animal populations

7.1 The Department of Agriculture, Environment and Rural Affairs (DAERA) aims to progressively reduce levels of bTB in NI with the ultimate long term aim of eradication. In January 2020, following the restoration of the NI Executive, Edwin Poots, MLA, was appointed Minister of Agriculture, Environment and Rural Affairs. Since then the Minister has made clear that reducing, and ultimately eradicating, bTB from NI is one of his key priorities. The appointment of the Minister and the restoration of the devolved institutions has enabled significant progress to be made on the development of a new bTB Eradication Strategy for Northern Ireland.

7.2 Based upon recommendations made by the TB Strategic Partnership Group (TBSPG), an independent group established in 2014, and following a public consultation on the Department's response to those recommendations in late 2017/early 2018, the proposed Strategy is an integrated package of interdependent measures. As previously reported, in 2018, it was decided to take forward one of the TBSPG recommendations namely the establishment of the TB Eradication Partnership (TBEP) in order that it could work with DAERA in the further development and implementation of the bTB Eradication Strategy. An outline business case considering the financial implications of the Strategy was also

completed in early 2021, enabling officials to present their updated recommendations to the Minister in spring 2021.

7.3 As currently proposed, the Strategy consists of 21 recommendations across 6 thematic areas: Management, Oversight and Governance; Tools and Processes; Herd Health Management; Research; Finance and Funding; and Wildlife.

7.4 Following Ministerial consideration, a further public consultation sought views on some elements of the new Strategy, including a proposed wildlife intervention; changes to compensation arrangement; criteria on which IFNG testing takes place; and proposed new powers to test non-bovine animals for bTB issued in July 2021. Set out in three sections, the consultation document noted what has been done; what will be done and what could be done.

7.5 The first part set out those measures which have already been implemented to combat bTB including amongst others, more stringent interpretation of the single intradermal comparative cervical tuberculin test (SICCT) commonly known as the Skin Test, and improved disease surveillance at cattle abattoirs.

7.6 The second part set out the Cattle Measures proposals (themes relating to Management, Oversight and Governance; Tools and Processes; Herd Health Management; Research). As the Cattle Measures proposals were consulted upon in 2017 and there was general support for the proposals, these were not consulted upon again. There are, however, two elements not previously consulted upon that were subject to the consultation process;

- the criteria for compulsory use of the interferon gamma (IFNG) blood test; and
- the testing of non-bovines, in particular camelids and deer, for bTB infection.

7.7 The third part of the consultation contained two key elements;

- the proposed way forward on wildlife intervention to address the role of the badger population in disease spread. Wildlife intervention would be in the form of a non-selective badger cull using controlled shooting of free roaming badgers, as the predominant badger removal method, delivered and paid for by farmer led companies; and
- the Department's proposed measures regarding changes to the current compensation regime to rebalance the costs of the disease between public and private sector and encourage the necessary cultural changes. The proposals which were consulted on were, to introduce a maximum cap on the amount that may be paid for any one animal of £5,000, and in a phased basis reduce the level of compensation paid from its current level of 100% of market value, firstly to 90% and then subsequently to 75%.

7.8 The consultation and associated documents can be accessed at www.daera-ni.gov.uk/consultations/consultation-departments-proposed-implementation-and-next-steps-btb-eradication-strategy-northern .

7.9 This consultation closed on 10 September 2021 with over 3,300 responses received. Officials are currently considering and analysing these responses. Following consideration of the public's views and the scientific advice, the

Minister will decide on the way forward and seek Executive colleagues' endorsement of his chosen approach.

7.10 As noted above, enhanced disease controls recommended by TBSPG, which could be implemented in the absence of a Minister, have been in place since March 2018 in response to the steep increase in disease incidence seen in 2017 and the impact of these measures on earlier disease detection in chronic herds have been encouraging. These changes are listed below at paragraph 7.17.

7.11 Work is also progressing to plan for implementation of further disease control measures as required by Regulation (EU) 2016/429. Most significantly, legislation to amend the Tuberculosis Control Order (NI) 1999 (as amended) will be required to give effect to the requirement for a pre or post movement test. Officials have been preparing a draft amendment order and associated consultation documents, including a draft regulatory impact assessment in addition to engaging with stakeholders on these changes.

7.12 Key aspects of the surveillance programme in NI:

• All herds are subject to annual tuberculin skin testing in compliance with Commission Delegated Regulation (EU) 2020/689. A more severe interpretation of the SICCT results is used to increase sensitivity of testing in all OTW breakdowns and at any test when considered epidemiologically appropriate by Veterinary Officers. Mandatory use of 'severe interpretation' was significantly increased in March 2018.

• In NI the IFN-gamma test is used in parallel to the skin test to maximise disease detection in OTW breakdown herds which meet defined eligibility criteria.

• Slaughter surveillance is by DAERA employed Meat Inspectors under the immediate supervision of the designated DAERA employed OV. Post-mortem and any additional laboratory test results are recorded on the Animal and Public Health Information System (APHIS) database. This ensures prompt actions are taken by field staff.

• All NI herds are allocated an OT status as defined in former Council Directive 64/432/EEC with work ongoing to ensure that status allocation reflects the amended requirements set out in Commission Delegated regulation (EU) 2020/689. In addition, OTW is applied: to any herd with more than one skin reactor (reduced from more than five skin reactors in March 2018) without regard to disease confirmation; and at veterinary discretion in further situations, when it is deemed epidemiologically appropriate.

• Movement of cattle from OTW and OTS herds is immediately restricted via APHIS.

• Identification, Registration and Movement information and disease data (skin test, post-mortem and laboratory test results) are all held on the integrated APHIS database, facilitating prompt and accurate disease tracing to and from breakdown herds.

• No herds are exempt from at least annual testing. Herds test more frequently if disease is suspected or confirmed, or if deemed at increased disease risk. Herds

deemed at risk to OTW breakdown herds are currently tested at 5 monthly intervals, and when OTF status is restored to OTW herds, the herd must complete at least 2 tests at 6 monthly intervals before returning to annual testing. A total of 36,375 herd tests were completed in 2020.

• The average interval between herd tests has fallen in recent years (from 8.6 months in 2014 to 7.03 months in 2019) as a result of increased efforts to identify infected herds more promptly. Despite some disruption caused by the pandemic, the average interval only increased marginally to 7.43 months in 2020. The overall decrease is in part attributable to changes introduced in March 2018 (Introduction of CH2 test in OTW breakdowns).

Wildlife Policy in NI:

7.13 DAERA recognises that involvement of wildlife, mainly badgers, must be addressed if eradication is to be achieved. Deer are not currently considered significant in the epidemiology within NI but remain under review. A research project on the role of deer in bTB in NI is currently underway.

7.14 The role of badgers in the epidemiology has not been quantified but DAERA continues to work in partnership with its science provider, Agri-Food and Biosciences Institute (AFBI), to identify knowledge gaps and to explore research and development options to complement current work. Both the unique 5-year 'Test and Vaccinate or Remove' (TVR) wildlife intervention research project, which was completed in 2018 and the long-standing Road Traffic Accident (RTA) survey (13.7% of the 248 RTA badgers submitted were M. bovis culture positive in 2020) have provided epidemiological information to inform our future approach.

7.15 The TVR project field work finished in October 2018. Since then a number of research papers have been published with a number of others still going through the peer review process. Links to papers published to date are attached separately. Further details are at www.daera-ni.gov.uk/articles/test-and-vaccinate-or-remove-tvr-wildlife-intervention-research

7.16 In the past three years, badger sett surveying work has taken place in four areas of high cattle bTB incidence and badger density, in which TB has been confirmed in the badger populations.

7.17 Programme developments

• Since March 2018, the threshold for Officially Tuberculosis Free Withdrawn (OTW) status has been reduced from more than 5 non-visibly lesioned reactors to more than 1 non-visibly lesioned reactor.

• The use of 'severe interpretation' has been significantly increased to remove infection earlier and reduce the risk of leaving undisclosed infected animals in a herd at de-restriction.

• Veterinary Officers review previous skin test results in all new OTW herds. Any animal which was inconclusive at standard interpretation at a breakdown test (where bTB had been confirmed at slaughter and /or laboratory, or more than 1 reactor during breakdown) within the past 3 years is compulsorily removed.

Veterinary Officers also have discretion to remove any other animals considered higher risk on the basis of historic skin test results.

• OTW herds now require an additional 6 monthly test following de-restriction. This means that all OTW herds must have at least 4 consecutive clear herd tests (2 clear breakdown tests then 2 clear tests at 6 month intervals following de-restriction) before returning to annual testing.

• A Reactor Quality Assurance pilot to establish baseline data on skin reactors started in November 2017. Skin test reactions were assessed and blood samples taken for IFN-gamma testing. Field data collection was completed in autumn 2018 and the findings have been evaluated and published. The results of the pilot will be used to inform and enhance counter-fraud policy, and give further assurances regarding the conduct of the skin test.

• In NI the delivery of bTB testing is managed by a public services contract focussing on performance and relationships, finding disease where it exists more effectively and delivering herd health and biosecurity messages. As a result of this, delivery standards have continued to improve.

• Since 2018, focus has been towards use of new mapping tools and better use of data to describe and demonstrate the disease situation in particular areas throughout NI. Quarterly performance reports include updates to inform private veterinarians of the details of their disease outbreaks. This information can also be demonstrated on maps to indicate the relative geographical organisation of bTB in the area in which they work. NI legislation allows information regarding disease outbreaks to be shared with any veterinarian.

• DAERA have developed the discussion with private veterinary contracted suppliers at annual performance review meetings which take place between the government authority veterinary officers and each contracted veterinary practice. The interactive nature of the new mapping tools are useful to get better knowledge and ideas for disease control strategies in the local areas affected.

• An annual mandatory half day training course provided by the Department is requirement for Approved Veterinary Surgeons (AVS) in order to continue carrying out bTB Testing on behalf of DAERA. Close links with the DAERA College of Agriculture, Food and Rural Enterprise (CAFRE) has assisted DAERA to avail of new technologies and logistics to deliver an online bTB Training package for AVSs. Year 5 of the bTB Contract ended on 31 march 2021 and by 27/07/2021 333 AVS had completed their online bTB training. The package included important updates and overviews of the programme and keynote epidemiology perspectives from the internationally renowned Dr Tom Ford, Head of Immunology at AFBI NI,

• Each Approved Veterinary Surgeon (AVS) testing more than 500 cattle in a 12 month period is provided with 6 monthly report which provides their ranking in relation to 4 key metrics that assess aspects of their bTB testing performance. Variations from normal parameters are targeted for field audit. DAERA continues to assure the ability and standard of contracted vets at the approval inspection. Random inspections carried out since 2016 have demonstrated improved compliance with the very particular standards set in the Annex B 64/462. The

focus is now being shifted to a regime of 80% risk and targeted inspections and 20% of inspections based on a control population picked at random

• Details of the public services contract for delivery of bTB testing can be found at https://www.daera-ni.gov.uk/publications/tb-testing-services

• A biosecurity questionnaire is now carried out by an AVS for all herds at least once a year. This is used as a framework for a discussion between the herd keeper and his own vet around biosecurity and herd health to include specific risk factors regarding bTB and also other general disease risks. Herd keepers will be able to monitor changes in their biosecurity status from year to year and the AVS is able to provide herd specific advice. Guidance notes provided to AVSs are at https://www.daera-ni.gov.uk/publications/tb-testing-services

• The standardised bTB breakdown investigation form has been refined and is used at all breakdowns (except where there are unconfirmed lesions at routine slaughter) to enable better capture and analysis of epidemiological data. The form now contains 70 detailed questions which document evidence particular to each herd including bTB history, farming practise, wildlife, farm biosecurity and the presence of other diseases. Detailed mapping information is also obtained .The information collected is being analysed by the DAERA epidemiology unit to determine the characteristics and risk factors most common in chronic bTB breakdown herds. These findings will inform DAERA and the TB Eradication Partnership on what new control measures are required to tackle persistent breakdown herds.

8. A description of the organisation, supervision and roles of the parties involved in the eradication programme including at least:

(a) the authorities in charge of coordinating and supervising the implementation of the programme;

(b) responsibilities of all stakeholders involved.

8.1 The responsibility for the Northern Ireland bTB programme lies with the Department of Agriculture, Environment and Rural Affairs (DAERA). Veterinary Service Animal Health Group, under the leadership of the Robert Huey, Chief Veterinary Officer for Northern Ireland, has responsibility within DAERA for the delivery of the programme and development of policy.

8.2 Agri Food and Biosciences Institute (AFBI) provides scientific support for the NI bTB programme and undertakes DAERA sponsored research work into this disease. AFBI is an arms-length body of DAERA.

8.3 In 2018, the Department established the TB Eradication Partnership to provide independent advice on the development and implementation of the proposed bTB Eradication Strategy for Northern Ireland. A TBSPG recommendation, TBEP comprises a Chair and five members.

8.4 Members of the TBEP represent a wide range of backgrounds and experiences relevant to driving forward the eradication of bTB in Northern Ireland, including industry stakeholders, farmers and representatives with science, veterinary and environmental/conservation experience.

9. The estimated duration of the eradication programme.

9.1 The proposed new bTB Eradication Strategy for Northern Ireland acknowledges that eradication will be a long term project. The Strategy, along with its outline business case, envisages costs being incurred in the eradication of bTB over the next 40 years.

10. The intermediate targets of the eradication programme including at least:

(a) the expected annual decrease of the number of infected establishments;

(b) the expected annual increase of the number of disease-free establishments;

(c) the expected vaccination coverage, where relevant.

10.1 DAERA is committed to the eradication of bTB and has enhanced the current bTB programme in response to disease trends, with measures closely aligned to the requirements of the 2015 FVO mission.

10.2 As a consequence of this enhanced surveillance effort, the sensitivity of the NI programme has been improved. There had been a noticeable decrease in incidence levels during 2018 and 2019, however, since the end of 2019 disease levels are no longer in decline with herd incidence increasing from 7.85% at the end of 2019 to 8.44% in 2020. Herd incidence for the 12 months to the end of August stood at 8.59% with the current trend fairly static.

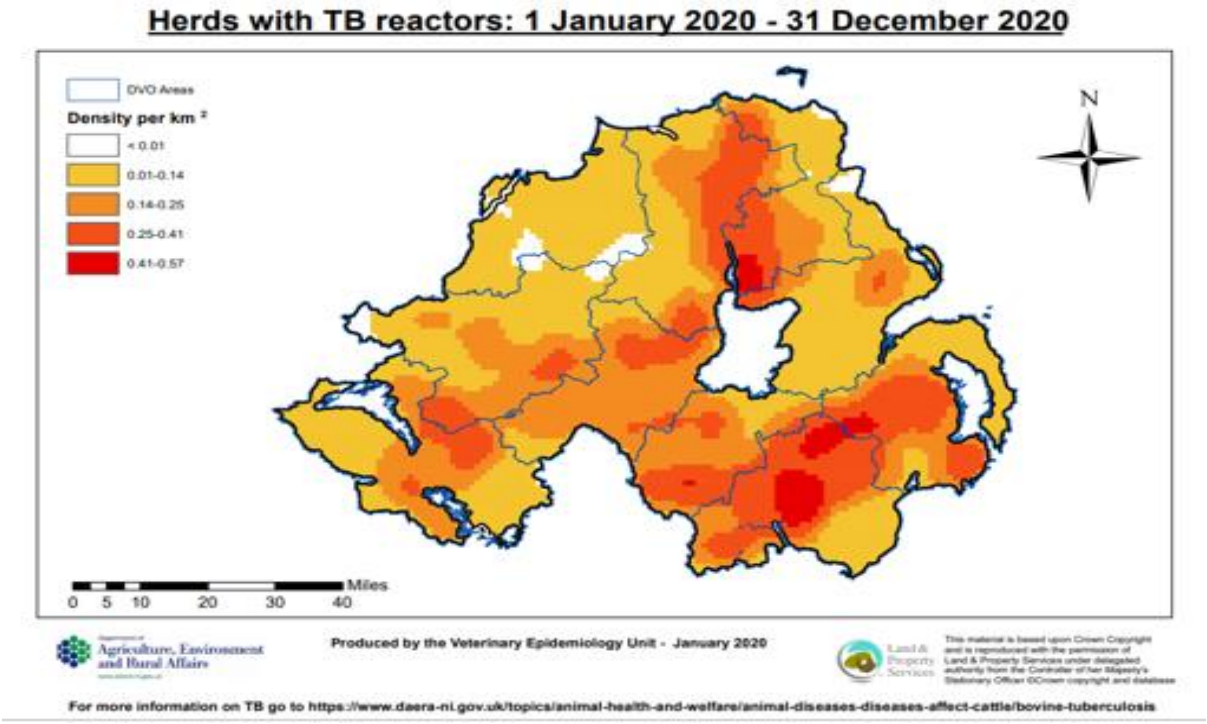
10.3 As noted above, the absence of progress since 2019 may be partly attributable to disruption caused by the Covid-19 pandemic. However, programme delivery has returned to normal in 2021 and other measures, such as the planned increase in IFNG testing can now be progressed. Similarly other recommendations included in the proposed bTB Eradication Strategy can now be progressed, with others, such as the proposed wildlife intervention and changes to bTB compensation arrangements subject to Ministerial approval and will require new legislation. It is envisaged that 2022 will be a key year in the evolution and delivery of Strategy recommendations and it is anticipated that this work will begin to bear fruit in terms of reduced disease levels over the next two calendar years. Should a 20% target reduction in herd incidence be achieved by the end of 2023, based on the current baseline of 8.59%, this would give an interim target herd incidence figure of 6.87%.

Attachments:

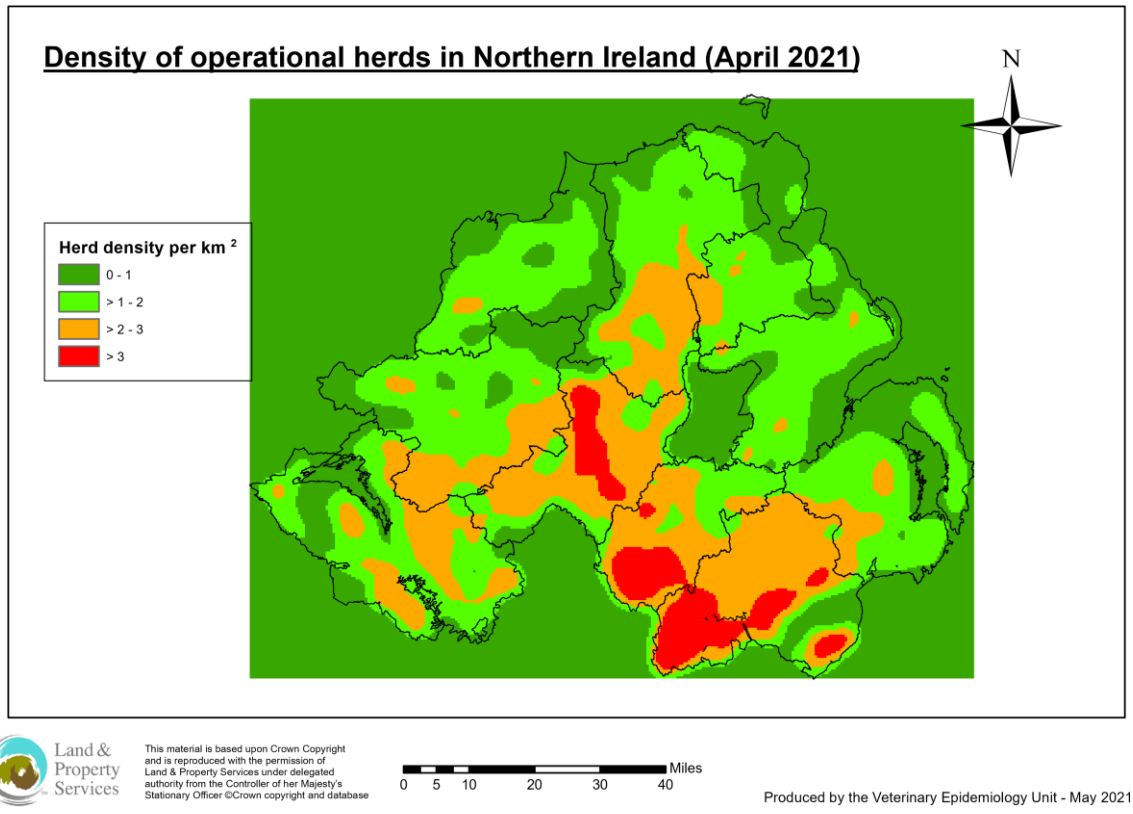
i. Herd incidence heat map for 2020.
ii. Map of herd density in NI April 2021
iii. List of papers published as part of the TVR research project.
iv. Other TB related research papers published since January 2019

Appendix to NI TB Programme submission for 2022

The map below shows the density of herds with TB reactors in 2020.



Map showing density of operational herds



Published TVR research papers

Rossi, G., Crispell J., White, P.C.L., Lycett, S. J., Brough, T., Allen, A. R., Skuce, R. A., Presho, E. L., Gordon, S.V., Palkopoulou, E., Harwood, R., Ellis, R. J., Smith, G. C., Kao, R. R. (2020). Phylo-dynamic analysis of an emergent *Mycobacterium bovis* outbreak in an area with no previously known wildlife infections.

bioRxiv 2020.11.12.379297; doi: https://doi.org/10.1101/2020.11.12.379297.

This article is a pre-print and has not been certified by peer review.

Rossi, G., Crispell J., White, P.C.L., Lycett, S. J., Brough, T., Allen, A. R., Skuce, R. A., Presho, E. L., Gordon, S.V., Palkopoulou, E., Harwood, R., Ellis, R. J., Smith, G. C., Kao, R. R. (2021). Phylo-dynamic analysis of an emergent *Mycobacterium bovis* outbreak in an area with no previously known wildlife infections. *Journal of Applied Ecology*. (Accepted – in press).

Akhmetova, A., Guerrero, J., McAdam, P., Salvador, L.C.M., Crispell, J. Lavery, J., Presho, E., Kao, R.R., Biek, R., Menzies, F., Trimble, N., Harwood, R., Pepler, T., Oravcova, K., Graham, J., Skuce, R., du Plessis, L., Thompson, S., Wright, L., Byrne, A., Allen, A.R. (2021). Genomic epidemiology of *Mycobacterium bovis* infection in sympatric badger and cattle populations in Northern Ireland.

bioRxiv 2021.03.12.435101; doi: https://doi.org/10.1101/2021.03.12.435101.

This article is a pre-print and has not been certified by peer review.

Arnold, M.E., Courcier, E.A., Stringer, L.A., M^{c}Cormick, C.M., Pascual-Linaza A.V., Collins, S.F., Trimble, N.A., Ford, T., Thompson, S. and Menzies, F.D. (2021). A Bayesian analysis of a test and vaccinate or remove study to control bovine tuberculosis in badgers. *PLoS ONE*, **16**, e0246141. https://doi.org/10.1371/journal.pone.0246141

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Campbell, E.L., Menzies, F.D., Byrne, A.W., Porter, S., McBride, K.R., McCormick, C.M., Scantlebury, D.M., Reid, N. (2020). Grazing cattle exposure to neighbouring herds and badgers in relation to bovine tuberculosis risk. *Research in Veterinary Science***, 133,** 297-303. https://doi.org/10.1016/j.rvsc.2020.09.032

Courcier, E.A., Pascual-Linaza A.V., Arnold, M.E , M^{c}Cormick, C.M., Corbett, D.M., O'Hagan M.J.H., Collins, S.F, Trimble, N.A., M^{c}Geown, C.F., M^{c}Hugh, G.E., M^{c}Bride, K.R., M^{c}Nair, J., Thompson, S., Patterson, I.A.P. and Menzies, F.D. (2020). Evaluating the application of the Dual Path Platform VetTB test for badgers (*Meles meles*) in the Test and Vaccinate or Remove (TVR) wildlife research intervention project in Northern Ireland**.** *Research in Veterinary Science***, 130,** 170-178. https://doi.org/10.1016/j.rvsc.2020.03.007

Campbell, E.L., Byrne, A.W., Menzies, F.D., McBride, K.R., McCormick, C.M., Scantlebury, D.M., Reid, N. (2019). Interspecies visitation of cattle and badges to fomites: A

transmission risk in bovine tuberculosis? *Ecology and Evolution*, **9**, 8479-89. DOI**:**10.1002/ece3.5282

Menzies, F.D., M^{c}Cormick, C.M., O'Hagan, M.J.H., Collins, S.F., McEwan, J., M^{c}Geown, C.F., McHugh, G.E., Hart, C.D., Stringer, L.A., Molloy, C., Courcier, E.A., Burns, G., McBride, S.J., Doyle, L.P., M^{c}Bride, K.R., McNair, J., Thompson, S., Corbett, D.M., Harwood, R.G. and Trimble, N.A. (2021). Test and vaccinate or remove: methodology and preliminary results from a badger intervention research project. *Veterinary Record*, **189**, e248. https://doi.org/10.1002/vetr.248

O'Hagan, M.J.H., Gordon, A.W., M^{c}Cormick, C.M., Collins, S.F., Trimble, N.A., M^{c}Geown, C.F., McHugh, G.E., M^{c}Bride, K.R. and Menzies, F.D. (2021). The effect on ranging behaviour after selective removal of bovine tuberculosis test positive badgers (*Meles meles*) using a test and vaccinate or remove intervention in Northern Ireland. *Epidemiology and Infection*, **149**, e125. https://doi.org/10.1017/S0950268821001096

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